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**NUCLEAR REACTOR TECHNOLOGY
AND SCIENTIFIC COMPUTATIONS**

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**VERIFICATION AND VALIDATION
ACTION MATRIX SUMMARY FOR AXLIB4 (U)**

By

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PROJECT: PHYSICS CODE CERTIFICATION

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**TITLE: VERIFICATION AND VALIDATION ACTION MATRIX
SUMMARY FOR AXLIB4**

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I. SUMMARY

References 1 and 2 describe a series of action items to be completed for certification of reactor analysis computer codes used in Technical Specifications development and for other safety and production support calculations. This document identifies the work performed and documentation generated to satisfy these action items for the Reactor Physics computer code AXLIB4. Each action item is discussed with the justification for its completion. Specific details of the work performed are not included in this document but are found in the references. The validation and verification effort for the AXLIB4 code is completed.

II. INTRODUCTION

References 1 and 2 describe a series of action items to be completed for verification and validation of reactor analysis computer codes used in Technical Specifications development and for other safety and production support calculations. These requirements have been organized into an action matrix. Each action item describes a different type of information and documentation that must be assembled for each code to be certified. The action matrix serves as a useful tracking tool for monitoring completion of the certification process for individual codes.

Figure 1 shows the present status of the action matrix for the computer code AXLIB4. As can be seen in the figure, all the requirements for certification of the code have been completed with review of this document and its associated references satisfying the review process. The rest of this document gives the justification for checking each box and identifies all relevant reference documentation. This material forms the basis for the required validation reviews. The action matrix divides the activities into five groups: Basics, Theory, Experiments, Benchmarks, and Conclusions. The remainder of this report utilizes this structure and format.

III. ACTION MATRIX

III.1. BASIC REQUIREMENTS

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III.1.1 User's Manual in Place

Since AXLIB4 is not a stand-alone code but it is executed by a driver code LLAP³, the User's manual requirement is not applied.

III.1.2 Configuration Control Plan

The Configuration control plan for AXLIB4 code is given in Reference 2. Configuration control of the AXLIB4 code is implemented by following Procedure No. TP-90-018: *Responsibilities of Technical Proprietors for Configuration Management Using SCMS*. The proprietor intends to install a configuration controlled version of AXLIB4 on the IBM 3090 and on the SRS VAX system. All required forms have been completed and installation on all systems is in progress.

III.1.3 Code Portability

AXLIB4 is intimately tied to the JOSHUA system, which is machine dependent. Therefore, the portability of AXLIB4 is dependent upon the portability of the JOSHUA system. The JOSHUA system was originally written on the IBM mainframes at the SRS and currently runs on the IBM 3090. In addition, the JOSHUA system and most of the important reactor physics codes that operate under it have been converted to run on the SRS VAX network and on the Westinghouse Hanford VAX system. Further portability of AXLIB4 is dependent on portability of JOSHUA. Limited portability of AXLIB4 has been demonstrated and additional portability can be implemented if the need arises.

III.2 VERIFICATION OF THEORY

III.2.1 Appropriate Theory

AXLIB4 solves the time dependent one dimensional multigroup neutron diffusion equation by a finite difference method. Neutron diffusion theory is well developed theory and is described in many Nuclear Engineering books.

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III.2.2 Theory Documented

Detailed descriptions of solutions to the diffusion equation can be found in the open literature. The AXLIB4 implementation of the theory is thoroughly documented in References 4 and 5.

III.2.3 Coding Consistency

AXLIB4 was developed before the current validation and verification requirements were in place and as a result the verification performed at the time was not documented sufficiently. To meet the requirement for this part, AXLIB4 source code was inspected line by line to insure the consistency of the code.

III.2.4 Theory Verified Conceptually

The AXLIB4 code theory is summarized in References 4 and 5. Since no new theoretical development is introduced, the basic theory documented in the open literature provides conceptual verification of the code theory as required.

III.2.5 Theory Verified by Experiment

AXLIB4 uses diffusion theory which is well known and is verified in open literature. The extensive operations history of AXLIB4 in conjunction with the code validation discussed below is sufficient to establish that the code is functioning as intended. The validation process is described in reference 5.

III.2.6 Theory Documentation Adequate

The theory documentation in references 4 and 5 together with the open literature is adequate for verification of the AXLIB4 code.

III.3 VALIDATION BY EXPERIMENTS

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There was no action for this part. Validation has been performed by benchmarking.

III.4 VALIDATION BY BENCHMARKING

III.4.1 Benchmark Requirements Identified

Benchmarks have been performed by comparing AXLIB4 results to the analytical solutions of two test problems as reported in Reference 5.

III.4.2 Similar Code Comparison

Since exact solution comparison is available, similar code comparison is not necessary.

III.4.3 Exact Solution Comparison

Test problem solutions of AXLIB4 were compared to the analytical solutions as described in Reference 5.

III.4.4 Industry Benchmark Comparison

Since exact solution comparison is available, industry benchmark comparison is not necessary.

III.4.5 Comparisons Documented

The results of the successful benchmarking are documented in Reference 5.

III.4.6 Benchmark Documentation Adequate

The benchmarking of AXLIB4 is described in Reference 5. This document provides adequate documentation.

III.4.7 Verification Review

The technical review of the Verification, Validation, and Benchmarking

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Report for AXLIB4 satisfies the verification review.

III.4.8 Verification Completed

The technical review of the Verification, Validation, and Benchmarking Report for AXLIB4 signals the completion of the verification process.

III.5 CONCLUSIONS

III.5.1 Standard Set of Test Problems

A standard set of test problems has been developed and documented in Reference 6.

III.5.2 Validation/Benchmarking Review

The technical review of the Verification, Validation, and Benchmarking Report for AXLIB4 satisfies the validation/benchmarking review.

III.5.3 Validation/Benchmarking Completed

The technical review of the Verification, Validation, and Benchmarking Report for AXLIB4 signals the completion of the validation/benchmarking process.

Figure 1

Verification and Validation Plan Action Matrix for AXLIB4

Basics

- User Manuals in Place
- Configuration Control Plan
- Code Portability

Theory

- Appropriate Theory
- Theory Documented
- Coding Consistency
- Theory Verified Conceptually
- Theory Verified by Experiments
- Theory Documentation Adequate

Experiments

- Tests in Experimental Facilities
- Tests in Operating Facilities
- Data from Operating Facilities
- Test Data Documented
- Appropriate Data Quality
- Validation Performed
- Validation Documentation Adequate

Benchmarks

- Benchmark Requirements Identified
- Similar Code Comparison
- Exact Solution Comparison
- Industry Benchmark Comparison
- Comparisons Documented
- Benchmark Documentation Adequate

Conclusions

- Verification review
- Verification Completed
- Standard Set of Test Problems
- Validation/Benchmarking Review
- Validation/Benchmarking Completed

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